

AMENDMENTS TO THE SPECIFICATION

On page 1, please replace the paragraph beginning on line 9 with the following paragraph:

Such a use, with a porous material being employed, was earlier described in GB-A-1 535 481. The porous material employed in this document consists of mineral carriers which are inert with respect to water, to the hydrophobic substance to be used as extractant, and to the compound to be extracted. Examples of suitable mineral carriers mentioned are pumice, kieselguhr, bauxite, alumina, carbon, or silicates. The particles preferably have a size in the range of $\theta,4$ 0.1 mm to 5 cm. It is stated that the pore size is critical only to the extent that it should be large enough to permit penetration of the compound to be extracted, of the extraction solvent, and of the regeneration liquid.

On page 2, please replace the paragraph beginning on line 1 with the following paragraph:

The invention consists in that when a porous material of the known type mentioned in the opening paragraph is used, it has a surface which will be wetted more readily by the hydrophobic substance ~~immobilised~~ immobilized in the pores of an average diameter in the range of $\theta,4$ 0.1 to 50 μ m than by the aqueous solution, with the proviso that at least 60% of the hydrophobic substance can be

extracted from the pores by a liquid wholly made up of the constituents to be extracted.

On page 2, please replace the paragraph beginning on line 23 with the following paragraph:

It was found that, in general, optimum results can be obtained when using a material having an average pore diameter in the range of ~~0,2~~ 0.2 to 15 μm .

On page 2, line 27 through page 3, line 12, please replace the paragraph with the following paragraph:

The hydrophobic ~~immobilised~~ immobilized material may be solid matter as well as a liquid. If the ~~immobilised~~ immobilized material is a solid, preference is given to a polymer which swells in the hydrophobic substance to be extracted. Examples of polymers which are suitable for use within the framework of the invention include polymethyl(meth)acrylate, styrene-acrylonitrile copolymer, and acrylonitrile-butadiene-styrene copolymer, all of which may be partially cross-linked or not. Preference is given in this case to polystyrene. If the ~~immobilised~~ immobilized material is a liquid, use is made of a liquid having the greatest possible affinity for the hydrophobic constituents to be extracted. Needless to say, this liquid should be virtually insoluble in the aqueous solution to be extracted and be so

~~immobilised~~ immobilized in the porous material that it cannot flow from the porous structure. Within the framework of the invention preference is given to the use of a liquid in the form of a glycerol ester of one or more, preferably unsaturated, fatty acids.

In general, favourable results are attained if the ~~immobilised~~ immobilized liquid is an oil, such as palmitic oil, olive oil, peanut oil, paraffinic oil, fish oil such as herring oil, linseed oil, and, in particular, soybean oil and/or castor oil.

On page 3, please replace the paragraph beginning on line 14 with the following paragraph:

Generally, favourable results are attained when using a material of which at least 15 vol.% of the pores is filled with the substance ~~immobilised~~ immobilized therein, with optimum results being obtained using a material of which at least 50 vol.% and not more than 95 vol.% of the pores is filled with the substance ~~immobilised~~ immobilized therein. Completely filled up pores may cause problems on account of swelling (solid matter) or expansion (liquid), which may lead to the dimensions of the porous material being interfered with or to the ~~immobilised~~ immobilized liquid bursting the pores. In the case of porous materials wholly filled up with a liquid hydrophobic substance being used, these difficulties can easily be overcome by mixing the filled material with unfilled (porous) material, so that the

generated excess can be absorbed during extraction. Alternatively, when a packed bed is used, the unfilled (porous) material may be deposited at the two ends of the bed as separate boundary layers. When these types of steps are taken, 100 vol.-%-filled materials may also be employed.

On page 4, please replace the paragraph beginning on line 19 with the following paragraph:

The porous polymer is generally used in the form of grains having an average particle diameter of θ , \pm 0.1 to 10 mm. Alternatively, the polymer may be employed in the granulated form, as well as in the form of membranes, fibres which may be hollow or not, etc. When in the form of a granulate or a powder, the porous polymer may be used in a packed bed, a fluidised bed, or a tank with stirring. Fibres which may be hollow or not are used in the form of fabrics and non-wovens, respectively.

On page 4, line 28 through page 5, line 7, please replace the paragraph with the following paragraph:

Particularly when a glycerol ester of one or more unsaturated fatty acids is employed to extract aromatic compounds from aqueous solutions, preference is given to a porous material obtained by a process such as described in DE-A-32 05 289. By this process a

structure may be obtained which has pores of an average diameter in the range of ~~0.1~~ 0.1 to 50 μm . Especially favourable results may be obtained when using polypropylene as porous material and soybean oil/castor oil as hydrophobic substance.

Needless to say, the materials according to the invention are not just suitable for extracting aromatic waste matter from aqueous solutions; extracting useful constituents such as biologically active constituents from usually highly dilute aqueous solutions is also within the bounds of possibility.

On page 6, please replace the paragraph beginning on line 25 with the following paragraph:

Powder I (~~7.38~~ 7.38 kg) was filled with ~~41.06~~ 11.06 kg of soybean oil to give a total of ~~48.44~~ 18.44 kg.

On page 6, please replace the paragraph beginning on line 28 with the following paragraph:

Powder II (~~8.04~~ 8.04 kg) was filled with ~~20.51~~ 20.51 kg of soybean oil/castor oil to give a total of ~~28.55~~ 28.55 kg.

The rate of flow of the liquid was 157 l per hour at a temperature of 24°C. The average overall aromatics content in the water to be purified was 840 ppm, the benzene content was 630 ppm, the toluene content 60 ppm.

On page 7, please replace the paragraph beginning on line 1 with the following paragraph:

In the case of powder I, the aromatics concentration in the effluent during an extraction process lasting well over 12 hours could not be measured. By then, the material had absorbed about ~~6,5~~ 6.5 wt.% of benzene and ~~8,5~~ 8.5 wt.% of aromatics, respectively.

On page 7, line 17 through page 8, line 6 please replace the paragraph with the following paragraph:

Example II

The column of Example I was now filled with ~~28,3~~ 28.3 kg of powder II, which was bounded on either side by a 5-10 cm thick layer of unfilled polypropylene granules. The rate of flow of the liquid was 300 l per hour at a temperature in the range of 11° to 13°C. The water to be treated had the following influent concentrations:

chloroform ~~0,5~~ 0.5 ppm

carbon tetrachloride 32 ppm

After 4 hours in the loaded state, with the contaminated water flowing upwards from the bottom, the column was regenerated with 103°C steam for 4 hours, with the steam being passed through the column in opposite direction to the water. The rate of flow of the steam was 4 kg per hour. The subsequent periods of loading also were 4 hours each. After eleven of such loadings the efficiency of the column

continued unchanged. The effluent concentrations of the treated water were measured by means of gas chromatography using an electron capture detector (ECD) and found to be below the detection limit for chloroform and carbon tetrachloride of < 10 ppb (parts per billion), except that in the case of carbon tetrachloride values < 60 ppb were measured occasionally.

After condensation of the steam, the chloroform and carbon tetrachloride were drawn off from a liquid separator as lower layer.

On page 8, line 8 through page 9, line 18, please replace the paragraph with the following paragraph:

Example III

In a manner analogous to that disclosed in Example I, two glass columns of 2 m in length and 23 cm in diameter were installed. These columns likewise were closed up at the top and the bottom with perforated screens having apertures of 1 mm in diameter. In order to achieve better distribution over the columns of the powder to be introduced, the columns were filled with stainless steel Pall® rings of 15 mm in diameter before being filled over a length of 190 cm with porous powder completely filled up with soybean/castor oil. In order to prevent clogging up of the perforated screens, the powder was bounded on either side by a 5-10 cm thick layer of identical material in the form of unfilled granules having a diameter of 3-4 mm.

The specification of the powder was as follows:

particle diameter	350-1000 μm
porosity	3 ml/g
average pore diameter	10 μm
degree of substitution	
with oil	72 wt. %

The amounts of powder differed per column: column 1 held ~~24,4~~ 24.4 kg and column 2 ~~29,4~~ 29.4 kg,

The columns were loaded alternately, with the water to be treated being pumped from the bottom upwards and regeneration with 105°C atmospheric steam taking place from the top downwards. The rate of flow of the steam was 4 kg per hour.

After 32 loadings and regenerations the efficiency of the columns proved unchanged.

The rate of flow of the liquid was 150 l per hour at a temperature of 6° to 13°C. The water to be treated had the following influent concentrations:

dichloromethane	195 ppm
chloroform	39 ppm
dichloroethane	32 ppm
benzene	272 ppm
toluene	137 ppm

The effluent concentrations were measured by means of gas chromatography using an electron capture detector (for chlorinated hydrocarbons) and flame ionisation (for benzene and toluene),

respectively, and found to be below the detection limits for chloroform, dichloroethane, benzene, and toluene of 10 ppb (for chloroform and dichloroethane) and 1 ppb (for benzene and toluene), respectively. The value measured for dichloromethane each time was ~~0,6~~ 0.6 ppm.

On page 9, line 20 through page 10, line 16, please replace the paragraph with the following paragraph:

Example IV

In a manner analogous to that disclosed in Example III, two columns were filled with Pall® rings, which this time had a diameter of 25 mm and were made of polypropylene. The columns were filled over a length of 180-190 cm, column 1 being filled with ~~28,3~~ 28.3 kg of powder and column 2 with ~~23,8~~ 23.8 kg. In order to prevent clogging up of the perforated screens, the powder was bounded on either side by a 5-10 cm thick layer of unfilled polypropylene granules having a diameter of 3-4 mm. The regeneration was carried out at a rate of flow of the steam of 2 kg per hour. After 11 loadings and regenerations the efficiency of the columns proved unchanged. The rate of flow of the liquid was 150 l per hour at a temperature of 15° to 20°C. The water to be treated had the following influent concentrations:

1,1-dichloroethane	2-3 ppm
cis-1,2-dichloroethane	30-50 ppm

1,1,1-trichloroethane 1-8 ppm

trichloroethene 0,1-0,3 0.1-0.3 ppm

Again, the effluent concentrations were measured by means of gas chromatography using ECD and found to be below the detection limits for said solvents, which were as follows:

1,1-dichloroethane < 50 ppb

cis-1,2-dichloroethene < 150 ppb

1,1,1-trichloroethane < 1 ppb

trichloroethene < 1 ppb

After condensation of the steam the organic substances were drawn off from a liquid separator as lower layer.

On page 10, line 18 through page 11, line 34, please replace the paragraph with the following paragraph:

Example V

In a manner analogous to that disclosed in Example IV, two columns were filled with Pall® polypropylene rings of 25 mm in diameter. Next, the columns were filled, over a length of 170 cm, with porous unfilled polypropylene powder. In order to prevent clogging up of the perforated screens, the powder was founded on either side by a 10-20 cm thick layer of unfilled polypropylene granules having a diameter of 3-4 mm.

The specification of the powder was as follows:

particle diameter 350-1000 µm

porosity	3 ml/g
average pore diameter	10 μ m
degree of substitution	
with oil	0 wt. %

Column 1 contained ~~7,22~~ 7.22 kg of unfilled powder, column 2 held ~~7,26~~ 7.26 kg. First, xylene was passed through the columns until the pores were wholly filled with xylene and there was xylene sticking to the powder particles.

Next, there was alternate loading of the columns, with the water to be treated again being pumped through the column from the bottom upwards. The regenerant used was xylene of 20° to 50°C, which was passed through the column from the top downwards. The rate of flow of the xylene was 55 l per hour. After being regenerated, the columns were emptied with nitrogen, with the powder retaining 30 kg of xylene as extractant.

The rate of flow of the waste water to be treated was 150 l per hour at a temperature of 20° to 50°C.

The water to be treated had the following influent concentrations:

o-cresol	70-250 ppm
2-methyl-4-chlorophenoxyacetic acid	50-160 ppm
2,4-dichlorophenoxyacetic acid	1-20 ppm
6-chloro-o-cresol	50-200 ppm
4-chloro-o-cresol	90-200 ppm
2-(2,4-dichlorophenoxy)propionic acid	4-7 ppm

2-(2-methyl-4-chlorophenoxy)propionic acid 3-13 ppm

4,6-dichloro-o-cresol 7-16 ppm

Measurement of the effluent concentrations this time was by means of liquid chromatography using UV detection. The two columns had the same effluent compositions, with the measured concentrations always being lower than the following values:

o-cresol	< 1 ppm
2-methyl-4-chlorophenoxyacetic acid	< 1 ppm
2,4-dichlorophenoxyacetic acid	< 0,4 <u>0.4</u> ppm
6-chloro-o-cresol	< 0,5 <u>0.5</u> ppm
4-chloro-o-cresol	< 0,5 <u>0.5</u> ppm
2-(2,4-dichlorophenoxy)propionic acid	< 0,2 <u>0.2</u> ppm
2-(2-methyl-4-chlorophenoxy)propionic acid	< 0,2 <u>0.2</u> ppm
4,6-dichloro-o-cresol	< 0,1 <u>0.1</u> ppm